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OPERATING MANUAL

FOR THE

MODEL 650

INTERFERENCE LOCATOR

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SPRAGUE INSTRUMENT OPERATIONS
MICRO TECH MFG. INC.
A Sprague Electric Company Subsidiary

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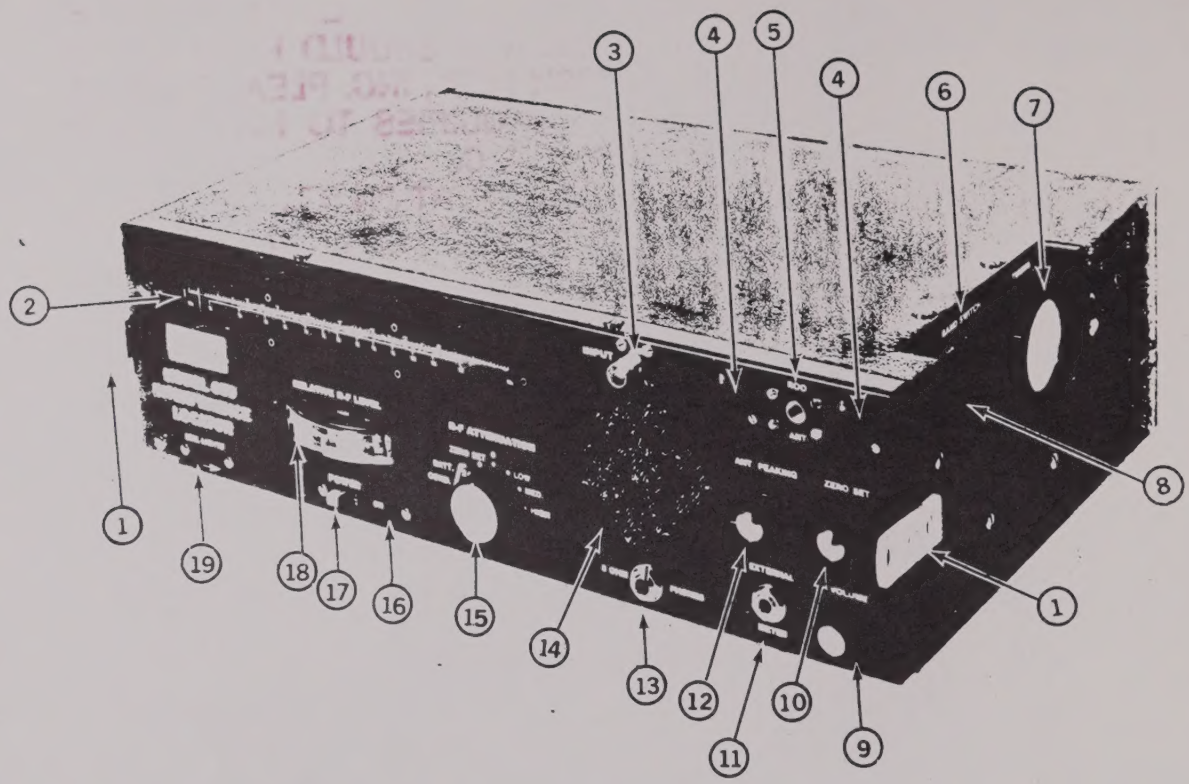

1. *Carrying strap bracket*
2. *Tuning dial*
3. *Input connector*
4. *Antenna mounting*
5. *Rod antenna connector*
6. *Band table*
7. *Tuning control*
8. *Band switch*
9. *Volume control*
10. *Zero set control*
11. *External meter jack*
12. *Antenna peaking control*
13. *Headphone jack*
14. *Speaker*
15. *Battery check/RF attenuation switch*
16. *Power indicator*
17. *Power switch*
18. *Battery check/RF level meter*
19. *Dial light switch*

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Operating Manual for the

Model 650 Interference Locator

1. Introduction

1.1 General. The Sprague Model 650 Interference Locator is a rugged portable instrument designed especially to meet the needs of electric utilities, laboratories, industries and others concerned with the detection and location of sources of low frequency (LF) r-f transmissions and interference. Special attention has been given to the design details which contribute to the reliability and convenience of use.

1.2 Operating Frequency and Sensitivity. The Model 650 Interference Locator covers from 50 kHz to 540 kHz in three tuning ranges with a sensitivity of 2 microvolts or better at all frequencies, for a 5% output meter deflection.

1.3 Application The Model 650 Interference Locator is designed for the rapid detection and location of LF signal sources. Other effective uses include the following:

a. Location of communications interference sources (corona noise, power line leaks) by electric utilities.

b. Maintenance programs, both preventive and otherwise, since many faults will begin to radiate r-f noise before actual failure occurs.

c. Laboratory and other testing and investigative applications. The instrument is useful as an r-f null detector or voltmeter when so calibrated.

d. Detection and location of sources of r-f transmissions within the frequency range of the instrument.

1.4 Specifications. Performance specifications and other data pertaining to the Model 650 Interference Locator are found in the Appendix.

1.5 Diagrams. The block diagram and schematic diagram necessary for the maintenance of the instrument are contained in this manual.

2. Circuits

2.1 General. The Model 650 Interference Locator is engineered around a solid-state superheterodyne circuit which provides a high degree of stability. Special circuitry has been incorporated to provide an instrument best adapted for interference location purposes. The frequency range covers from 50 kHz to 540 kHz in three switchable bands. These frequencies include various types of communications: subway and underground, hydronic, "wired-wireless," etc.

The instrument operates from a self-contained battery supply consisting of two 7.5 volt batteries, two 6 volt batteries and a single 1.5 volt dry cell. The battery life under normal usage is approximately 100 hours. When replacement is necessary, refer to Paragraphs 4.3 and 4.11 of this manual, which lists the required batteries by NEDA type number. Auxiliary power supplies are available.

2.2 Block Diagram. The block diagram for the complete instrument is shown in Figure 1.

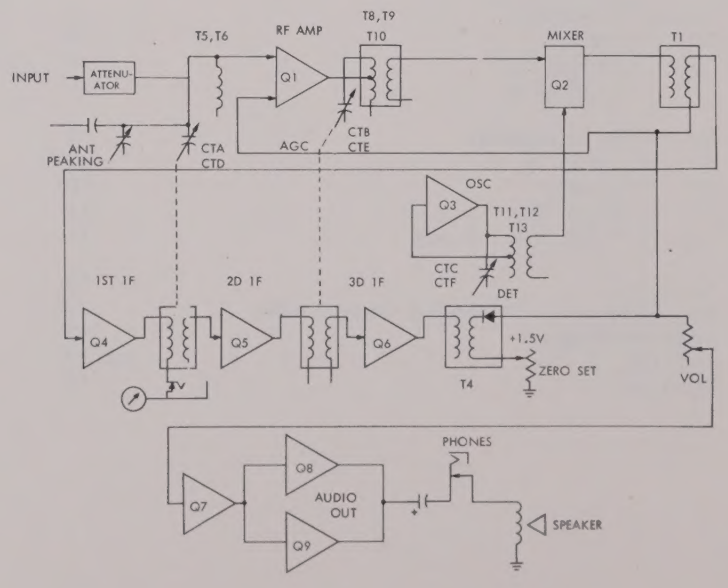


Figure 1

2.3 Theory of Operation. The circuitry used in the Model 650 Interference Locator is that of a superheterodyne receiver with the necessary modifications and additions to adequately cover the frequency range intended, insure stable operation under rugged conditions and long use, with a minimum of weight.

An intermediate frequency (IF) of 38 kHz is used for the frequency range of 50 kHz to 110 kHz (Band 1) and an i-f of 85 kHz is used for the 110 kHz to 540 kHz range (Bands 2 and 3). Each i-f stage contains one transformer, tuned inductively (85 kHz) or through variable capacitors (38 kHz) to pass the i-f frequencies.

From the antenna connector, the signal passes through the attenuator to Q1 r-f amplifier. The output of this amplifier is mixed with the signal from the local oscillator Q2 in mixer stage Q3. This produces the appropriate i-f signal. This signal is then amplified in Q4 first i-f stage and Q5 second i-f amplifier stage. The third i-f stage is Q6 whose output is applied to a single-tuned output transformer through diode D1, where detection takes place. The resultant audio signal then passes to the audio gain control, and the rectified current from diode D1 is injected into the a-g-c filter, then to the first i-f stage and the r-f amplifier. The Q4 collector current is monitored by a meter which shows an approximate logarithmic function of the r-f input signal.

The audio gain control applies signal to Q7 audio amplifier-driver which is applied to Q8, Q9 complementary pair, whose output is applied either to the speaker or the 8 ohm headphone jack.

2.4 Batteries. A 12-volt battery supplies power to the i-f amplifier, audio driver and audio output transistors.

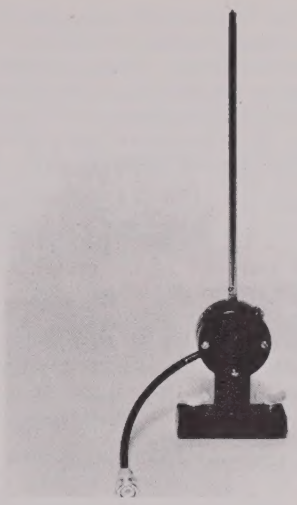
A 15-volt battery powers the tuner (front end). The 15-volt battery also provides a 1.5 volt bias to the first i-f amplifier, Q4.

A separate 1.5 volt D-cell power the two lamps which illuminate the tuning dial scale and the meter scale.

3. Antenna Systems

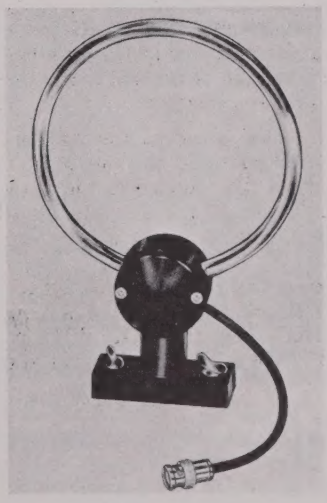
3.1 General. Two antennas are furnished with the Model 650 Interference Locator. These include a high-sensitivity rod antenna and a directional loop antenna. One optional antenna and two optional antenna accessories are available. Connections for the two antennas furnished are described below.

3.2 High-Sensitivity Rod Antenna. The telescoping rod may be threaded directly into the ROD ANT connector for use as an adjustable vertical antenna. When the rod antenna is used in this manner, the r-f attenuator does not function. R-F attenuation may be accomplished by partially collapsing the rod or by adjusting the ANT PEAKING control.
Remote operation may be achieved by screwing the rod into the antenna base and connecting the coaxial antenna lead (through an extension cable) to the INPUT connector.



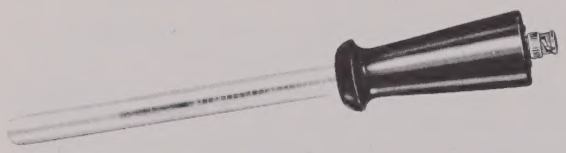
3.2.1 Applications. The rod antenna provides maximum sensitivity to signals but it is non-directional. However, the source of interference or r-f transmission can be found by using the triangulation procedure (taking readings at several compass points and noting the direction of increasing signal strength). When using this method, the controls on the instrument must be maintained in the same position once they are set initially. This will avoid confusing signal strength indications.

3.3 Directional Loop Antenna. This direction-finding antenna is provided with a mounting base which fastens directly to the top panel connectors on either side of the ROD ANT connector by means of two quick-connect fasteners. The coaxial antenna lead connects to the INPUT coaxial socket.



3.3.1 Applications. The directional loop antenna is used to determine the direction from which the interference or r-f radiation is coming. This is accomplished by rotating the entire instrument in the direction of the *weakest* signal as indicated on the RELATIVE R-F LEVEL meter. The direction of the source will be perpendicular to the plane of the loop.

3.4 R-F Probe Antenna. This is an optional accessory used with a coaxial extension cable connected to the INPUT connector. The cable is also an option.

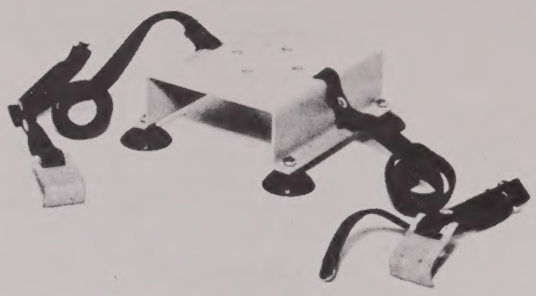


3.4.1 Applications. When an interference source has been localized to a small area, the r-f probe antenna is useful for pinpointing purposes. By inserting the probe into and around electrical installations, machinery, wiring and appliances, the source can be located with great accuracy. This antenna is used after the interference source has been localized by using either the loop or dipole antennas.
The probe is connected to one end of the 25-foot coaxial cable and the other end of the cable is connected to the locator INPUT connector.

SAFETY PRECAUTIONS

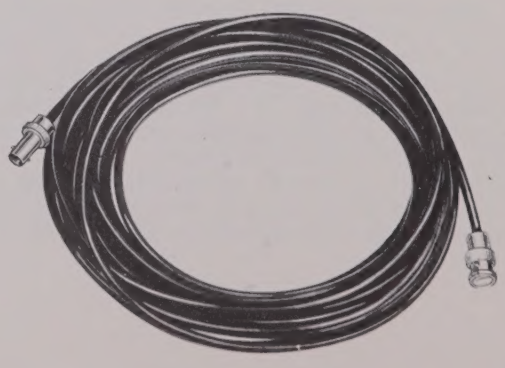
For maximum protection to users, the r-f probe antenna is tested to withstand 35,000 volts, 60 Hz. However, the probe should never be used in direct contact with the circuit under examination, whether it is "live" or not. The Model 650 Interference Locator should always be placed on the ground or floor when probing near energized equipment. Use extreme caution when using the probe in the vicinity of moving machinery.

3.5 Antenna Mounting. This is an adjustable web strap-suction cup mounting for the high-sensitivity rod antenna and the directional loop antenna. Intended for vehicular mounting, it is best installed on a flat roof, held in place with the suction cups and strapped securely to the rain gutters. This optional mount eliminates the need for a permanent installation and does not require holes to be drilled into the vehicle.



3.6 Short Coaxial Cable. This 8-foot cable with mating connectors for the INPUT connector on the instrument is used for adapting the Model 650 to standard vehicle radio antenna/s or external test equipment (for null-detection or voltmeter use). The impedance of this cable is 50 ohms.

3.7 Long Coaxial Cable. This 25-foot cable with mating connectors for the INPUT connector on the instrument is used for connecting remote antennas (such as the r-f probe antenna) to the Model 650 Locator. The impedance of this cable is 50 ohms.



4. Operation

4.1 General. The operating controls and procedures for using the Model 650 Interference Locator have been designed for ease of operation and to minimize operator error. When difficulty is encountered in using the instrument, read through the pertinent instruction paragraphs.

4.2 Attaching the Antenna. Select the antenna best suited to the individual application and attach it, with necessary cable if required, as outlined in Section 3.

4.3 Applying Power. Turn the power on by sliding the POWER switch to the ON position. Run through the check list below:

a. The red window to the right of the POWER switch indicates that power is applied.

b. Insure that all batteries are in good condition by rotating the R-F ATTENUATION switch to BATT. COND. 1 and BATT. COND. 2 and observing the RELATIVE R-F LEVEL meter for the following:

(1) If the meter indicates GOOD (green) in both switch positions, the batteries are alright.

(2) If the meter indicates REPLACE (red) in BATT. COND. 1 switch position, replace both 6 volt batteries (NEDA 6).

(3) If the meter indicates REPLACE (red) in BATT. COND. 2 switch position, replace both 7.5 volt batteries (NEDA 713).

On rare occasions, the single cell providing bias to pin 3 of battery socket J5 may be defective with the remainder of the 15 volt battery in good condition. In this case, the meter will not zero with the ZERO SET control. Replace the 7.5V battery (NEDA 713).

(To gain access to the battery compartment, remove the four quick-action fasteners on the rear of the instrument case.)

If the check out is satisfactory, the Interference Locator is ready for immediate use.

4.3.1 Auxiliary Power Supplies. To replace the battery power supply with either the Model 524 12 volt d-c supply or the Model 525 115 volt a-c supply, loosen the four quick-connect fasteners on the rear of the instrument case and unplug the power connector. Reverse the procedure to connect the auxiliary power supply. Both Models 524 and 525 are internally fuse-protected against instrument overload and vehicle regulator failure or power line surges.

4.4 Tuning Range Selection. Select the desired tuning range by rotating the BAND SWITCH on the side of the cabinet. The frequency ranges are listed for each band position on the BAND kHz table between the BAND SWITCH and the TUNING knob on the side of the cabinet.

4.5 Antenna Peaking. For maximum sensitivity, the individual antenna system in use must be peaked for that frequency in use. For all bands, set the ANT PEAKING control on the top panel for maximum deflection on the RELATIVE R-F LEVEL meter.

4.6 R-F Attenuation. Rotation of the R-F ATTENUATION switch to the O position provides maximum sensitivity, while the LOW, MED. and HIGH positions provide for increasing degrees of input signal attenuation.

4.7 Zero Set. The ZERO SET control is used to adjust the pointer to the zero point on the meter scale, while the R-F ATTENUATION is in the ZERO SET position. The zero point on the meter should be checked occasionally during operation and again when changing bands.

Since the ZERO SET control greatly affects the Model 650 sensitivity, misadjustment can cause the instrument to appear to be defective. Maximum instrument sensitivity will occur with the control fully counterclockwise.

4.8 Volume. Clockwise rotation of the VOLUME control increases the audio output level to either the internal speaker or external ear phones. Set this control to a comfortable listening level.

4.9 Tuning. Tune the instrument for the frequency desired by rotating the TUNING control located on the side panel. The frequency of the signals heard are read directly on the main tuning dial on the top panel. A convenient linear logging scale is also provided on each band.

Select that R-F ATTENUATION switch position (LOW-MED.-HIGH) which provides maximum meter deflection, but with the meter reading on the lower half of the scale. The VOLUME control should then be adjusted to provide a comfortable volume level.

4.10 Meter. The reading on the meter is directly proportional to the quasi-peak of the received r-f signal and is independent of modulation. Meter indications are also independent of the setting of the VOLUME control. The meter has an upper scale with an approximately logarithmic distribution. (The higher the meter reading, the greater the r-f input signal level). The logarithmic meter characteristic plus the R-F ATTENUATION switch position used to attenuate the r-f input signal allows the locator to be used over a wide range of input signal levels. For operator convenience, the lower scale is linear (0-100). This is helpful in duplicating readings, and as a general reference and logging scale.

4.11 Dial Lights. These can be turned on by sliding the spring-return DIAL LIGHTS switch to the right. If the lights are weak or inoperative, replace the 1.5 volt cell (NEDA 13).

4.12 Audio Output The panel-mounted speaker provides audio output unless headphones are used. Plugging 4 ohm to 16 ohm impedance headphones into the 8 OHM PHONES jack disconnects the internal speaker. This is helpful in noisy areas, for greater sensitivity to weak signals and for reasons of security.

4.13 External Meter. A jack is provided to permit use of an external remote meter (such as mounted on a vehicular instrument panel), which gives the same indication as the instrument RELATIVE R-F LEVEL meter. Note that when using the external meter, the BATT. COND. positions of the R-F ATTENUATOR switch will normally indicate low.

5. Location Procedures

5.1 General. There are three methods of monitoring and interpreting an r-f signal (noise or interference). You can:

(1) listen to the audio output from the built-in speaker.

(2) use the headphones plugged into the 8 OHM PHONES jack.

(3) observe the deflection of the meter indicator. Use of the meter is preferred because the human ear is sensitive to only relatively large changes in audio level. In cases where rotating the directional antenna produces only a small change in audio output, the meter readings must be relied upon in determining the direction from which the signal is coming.

5.2 Initial Readings. Initial attempts to locate the source of a signal will probably start quite far from the source. A signal from a low frequency station may be considerably stronger than the interfering signal. This will produce a maximum meter reading when the antenna is directed toward the radio or TV station, rather than toward the interference source. Figure 2 illustrates the start of an interference hunt, well away from the homes affected.

However, noise signals are generally very broad and can be heard above or below the frequency of the desired signal. By slight detuning, the signal from the station will be eliminated leaving just the interfering signal on the meter. It should now be possible to determine the direction of maximum interference by rotating the directional antenna and noting the changes in meter readings as shown in Figure 3. In this case, the investigation was carried out by a mobile unit.

NOTE: If the signal strength increases as the power line is patrolled, the direction heading is correct. If the signal decreases in strength, the opposite heading must be used. Additionally, there may be peaks and nulls in the signal as the investigator proceeds along the line. Each succeeding peak will be stronger as the source is approached. If each succeeding peak grows weaker, the direction of travel must be reversed. Figure 4 shows a Model 650 in use near a high tension line.

Figure 2

Figure 3

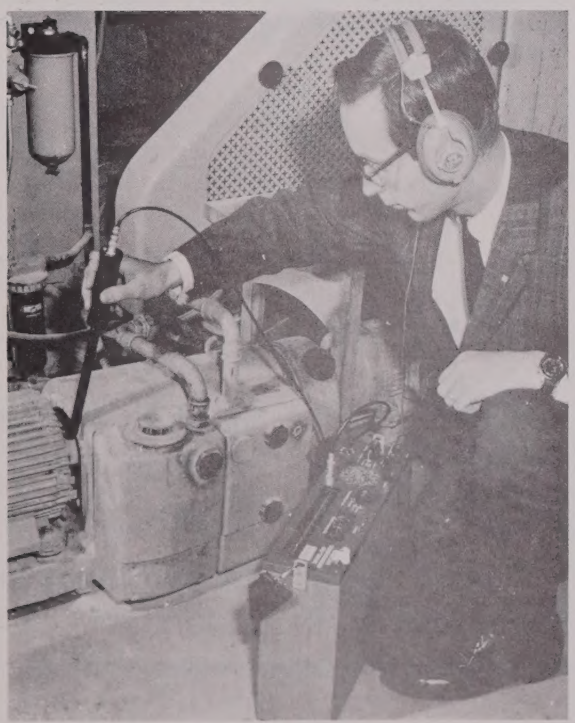


Figure 5

Figure 4

5.3 Final Readings. When the investigator is very close to the source of interference, the directional antenna will lose its effectiveness due to the strength of the signal from all directions. For precise location of the source, the r-f probe antenna should be used as shown in Figure 5. Here, the offending unit was found to be a badly arcing motor commutator.

6. Service and Maintenance

6.1 General. The Model 650 Interference Locator is designed and constructed to give long, trouble-free service but an occasional malfunction may occur. Most difficulties can be corrected by a qualified eletronic equipment repairman referring to the block diagrams, schematic diagram, parts list and alignment instructions. The accepted trouble-shooting procedures apply when servicing the Model 650. These

include looking for simple and obvious difficulties (loose antenna cable connections, run-down batteries, error in selecting proper frequency band, etc.), to the more detailed examinations such as internal visual and instrument checks (loose components, voltage and current checks, obviously damaged parts, etc.).

Instructions for returning the instrument to the factory are contained in the Warranty Terms found on the inside back cover of this Manual.

6.2 Alignment. The Model 650 Interference Locator should not be aligned by inexperienced personnel. Certain adjustments, particularly in the high-frequency circuits, are very critical and require familiarity with such equipment.

The signal generator used for alignment should contain an attenuator capable of reducing the generator output to 5 microvolts at all frequencies between 50 kHz and 540 kHz.

The accuracy of the dial calibration after realignment will be determined by the calibration accuracy of the signal generator used.

The input impedance of the Model 650 Interference Locator is approximately 50 ohms, therefore a generator with a 50 ohm output impedance must be used. Since the meter on the Interference Locator will be used as the tuning indicator, the signal generator may have either a modulated output or a continuous-wave (CW) output. Modulation will aid in identification of the signal generator's signal, particularly if the Model 650 is badly out of alignment.

Because the meter is in the automatic gain control (AGC) circuit, the generator output level must be kept low so the meter reading will not exceed 10 on the linear scale.

All adjustments should be made to produce maximum deflection of the tuning meter.

Before starting the alignment procedure, the meter zero adjustment must be made. The R-F ATTENUATION must be returned to the 0 position and left there for the duration of the alignment steps.

The position of the VOLUME control has no effect if a CW signal is used. If the signal generator is modulated, (approximately 30%) the control should be adjusted for a comfortable listening level.

6.2.1 Alignment Procedure. The following adjustments must be made before proceeding with the alignment of this instrument. All tuning should be for maximum signal on the RELATIVE R-F LEVEL meter. Adjust the signal generator for approximately 20% meter reading during the alignment.

Set the R-F ATTENUATION control to 0. Remove transistor Q3 while aligning the I-F stages and traps. Repeat each alignment step before proceeding to the next band.

BAND	DUMMY ANTENNA	SIGNAL GENERATOR CONNECTION	SIGNAL GENERATOR FREQUENCY	BAND SWITCH POSITION	DIAL SETTING	ADJUSTMENTS
85 kHz I-F	0.01μF	Junction of R28, C32	85 kHz	3	—	T4, T3, T2, T1, top and bottom
38 kHz I-F	0.01μF	Juntion of R28, C32	38 kHz	1	—	C65, C67, C72, C74, C82, C41, C39
1	200Ω non-inductive	INPUT	50 kHz 110 kHz	1	50 kHz 110 kHz	T11*, T5**, T7 slugs, C22, C7
2	200μ non-inductive	INPUT	110 kHz 250 kHz	2	110 kHz 250 kHz	T12*, T6**, T9 slugs, C25, C8
3	200μ non-inductive	INPUT	250 kHz 540 kHz	3	250 kHz 540 kHz	T13*, T7**, T10 slugs, C27, C9

*Indicates calibration adjustments.

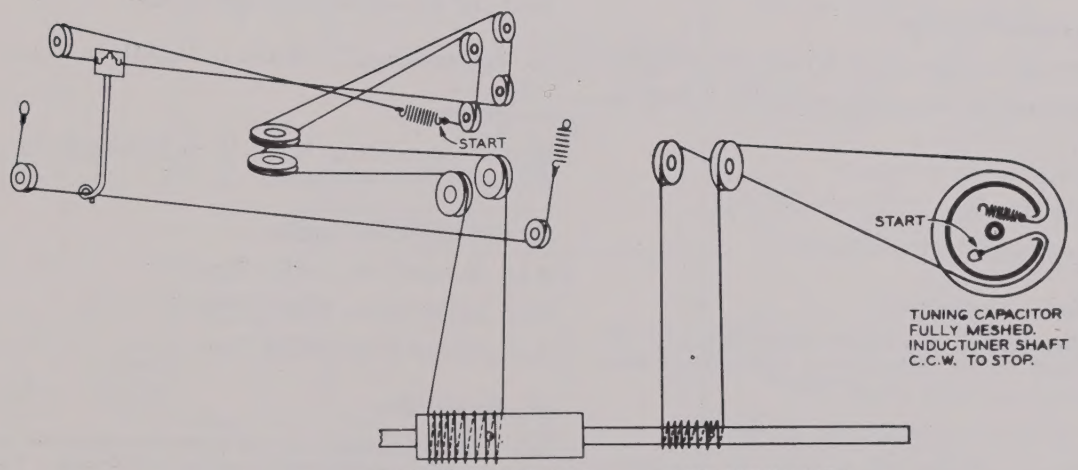
**Adjust r-f amplifier slugs so that rotation of ANT PEAKING control produces two peaks in receiver sensitivity at the high end and low end of the bands.

6.3 Voltage Chart. The measurements shown below must be made with a d-c vacuum tube or solid-state voltmeter with an input resistance of at least 11 megohms, otherwise the circuit under test will be loaded down and the reading will be in error. The Model 650 Interference Locator must be operated on fresh batteries for these measurements.

Transistor No.	Pin 1 Emitter	Pin 2 Base	Pin 3 Collector	Pin 4 Case or Source
Q1	13.20	0.92	0.00	0.48
Q2	1.60	1.90	13	0.00
Q3	0.24	−0.10	14	0.00
Q4	0.06	0.64	9.7	0.00
Q5	1.00	1.45	9.5	0.00
Q6	1.03	1.40	9.4	0.00
Q7	0.45	0.54	5.2	0.00
Q8	5.00	5.20	12	0.00
Q9	5.00	5.20	0.00	0.00

The voltages shown in the table were measured with a Hewlett Packard Model HP-410B vacuum tube voltmeter. The Model 650 meter was set to zero, with no signal input. All voltages are positive with respect to the chassis except as noted. Voltages may vary as much as 20% with different transistors.

6.4 Dial Cable Re-stringing. On rare occasions, the dial cable will require tightening or replacement. The diagram and photo shown below will aid in correcting troubles in this area. If the cord is replaced, use dial cord with an 0.030 diameter and follow the diagram below:


START
START
TUNING CAPACITOR FULLY MESHED. INDUCTUNER SHAFT C.C.W. TO STOP.
7 TURNS AROUND HUB, LOOP AROUND SET SCREW, THEN 1½ TURNS AND UP TO IDLER. POINTER CORD 56½ INCHES LONG, BETWEEN LOOPS.
7 TURNS AROUND SHAFT, DOWN THRU HOLE THEN 1½ TURNS AND UP TO IDLER. TUNING CORD 32½ INCHES LONG, LOOP TO END.
DWG NO. B-1288

DIAL CORD 0.030 DIAMETER

APPENDIX
Specifications and Performance Characteristics

1. Size.

1.1 The Model 650 is $4\frac{5}{8}$ in. high x $16\frac{3}{4}$ in. wide x $12\frac{1}{4}$ in. deep, including controls and undercabinet feet.

2. Net Weight.

2.1 17.5 pounds including batteries.

3. Mounting.

3.1 The instrument is mounted in a sturdy, compact, light-weight, grey-finished metal case with carrying strap.

4. Accessories Supplied.

4.1 Complete complement of dry-cell type batteries.

4.2 Combination collapsible/adjustable rod/dipole antenna.

4.3 Directional loop antenna.

4.5 Carrying strap.

4.6 Operating/Servicing Manual.

5. Optional Accessories.

5.1 Adjustable suction cup-mounted fitting for attaching loop or rod antennas on flat surfaces such as car roof tops (order Model 516).

5.2 R-F Antenna probe (order Model 511).

5.3 Eight-foot 50-ohm coaxial cable for connecting the instrument to a standard vehicle antenna or external test equipment (order Model 513).

5.4 Twenty-five-foot 50-ohm coaxial cable extension for connecting the instrument to remote antennas (order Model 512).

5.5 Headphones for use in high-noise level areas or for security reasons (order Model 514).

5.6 External meter for remote indication during mobile or other use (order Model 526).

5.7 12 volt d-c mobile auxiliary power supply for operation of instrument from vehicle cigaret lighter socket (order Model 524).

5.8 115 volt a-c auxiliary power supply for operation of instrument from commercial power lines (order Model 525).

5.9 Fiber case for transporting or storing instrument and accessories (order Model 523).

6. Tuning Range. 50 kHz to 540 kHz in 3 bands.

7. Sensitivity.

7.1 2 microvolts or better at all frequencies for a 5% output meter deflection.

8. Battery Power Supply.

8.1 15 volts (2 ea. NEDA Type 713)

8.2 12 volts (2 ea. NEDA Type 6)

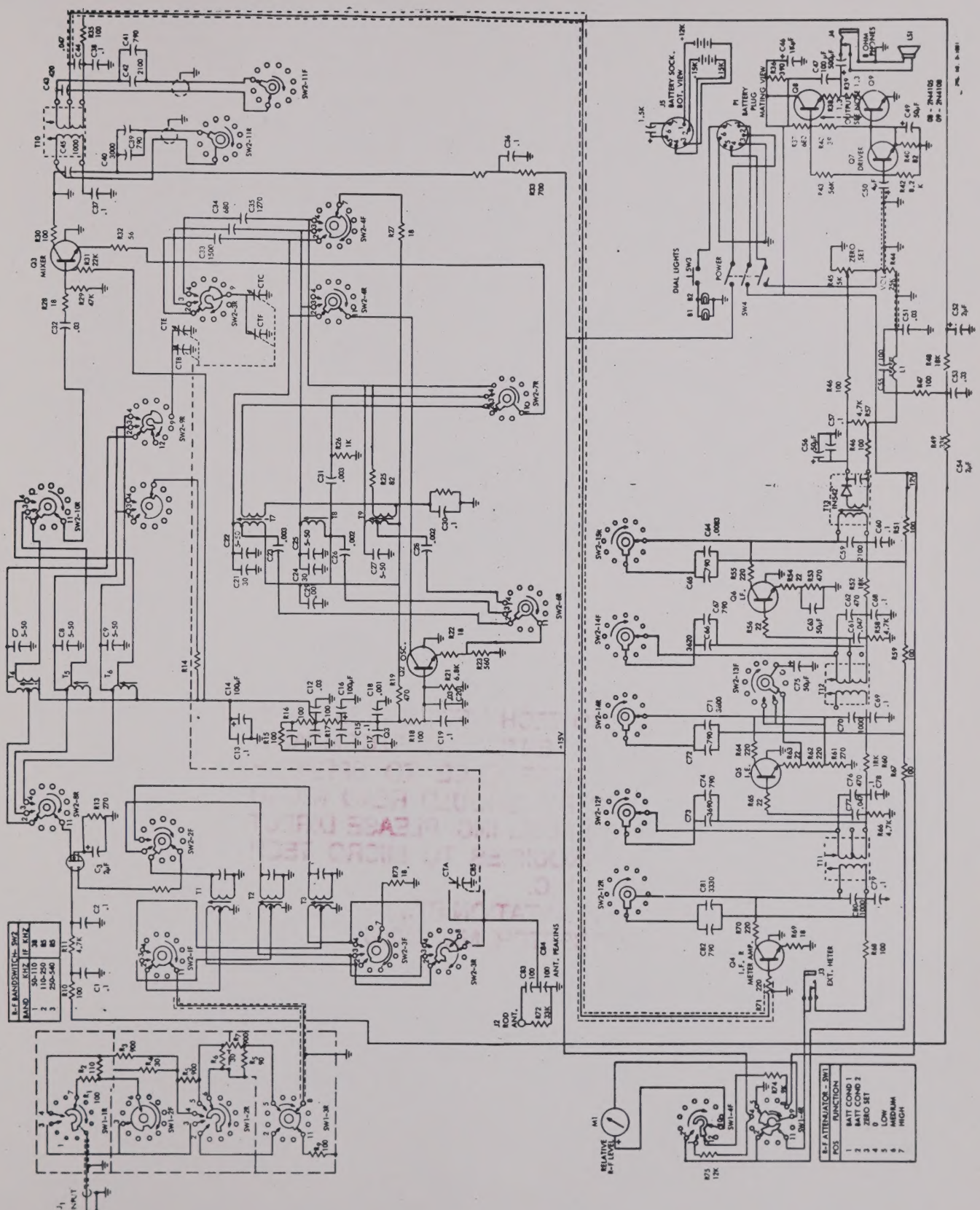
8.3 1.5 volt (1 ea. NEDA Type 13)

9. Battery Life.

9.1 One hundred hours of operation may be expected under continuous operating conditions. This is a variable which is extended under intermittent operating conditions.

10. Circuitry.

10.1 The Model 650 Interference Locator employs a high-gain, all solid-state AM superheterodyne circuit.


R.F. BAND SWITCH - SW2
BAND
KHZ
HI KHZ
1
150-300
300
2
110-250
85
3
250-540
R.F. ATTENUATOR - SW1
POS
FUNCTION
BATT COND 1
BATT COND 2
ZERO SET
LOW
MEDIUM
HIGH
J1 INPUT
J2 ANT.
J3 EXT. METER
J4 PHONES
J5 BATTERY SOCK. BOT. VIEW
P1 BATTERY PLUG MATING VIEW
DIAL LIGHTS
POWER
SW4
ZERO SET
OUTPUT LEVEL
RELATIVE R-F LEVEL
ANT. BALANCE
METER AMP
MIXER
OSC.
DRIVER
OUTPUT
-15V

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